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Grand Lake, Chicot County Arkansas

National Eutrophication Survey, Las Vegas, Nev

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16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT
ON
GRAND LAKE
CHICOT COUNTY
ARKANSAS
EPA REGION VI
WORKING PAPER No. 488

WITH THE COOPERATION OF THE
ARKANSAS DEPARTMENT OF POLLUTION
CONTROL AND ECOLOGY
AND THE
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JANUARY, 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Arkansas Department of Pollution Control and Ecology for professional involvement, to the Arkansas National Guard for conducting the tributary sampling phase of the Survey, and to those Arkansas wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Water Division of the Arkansas Department of Pollution Control and Ecology provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper series.

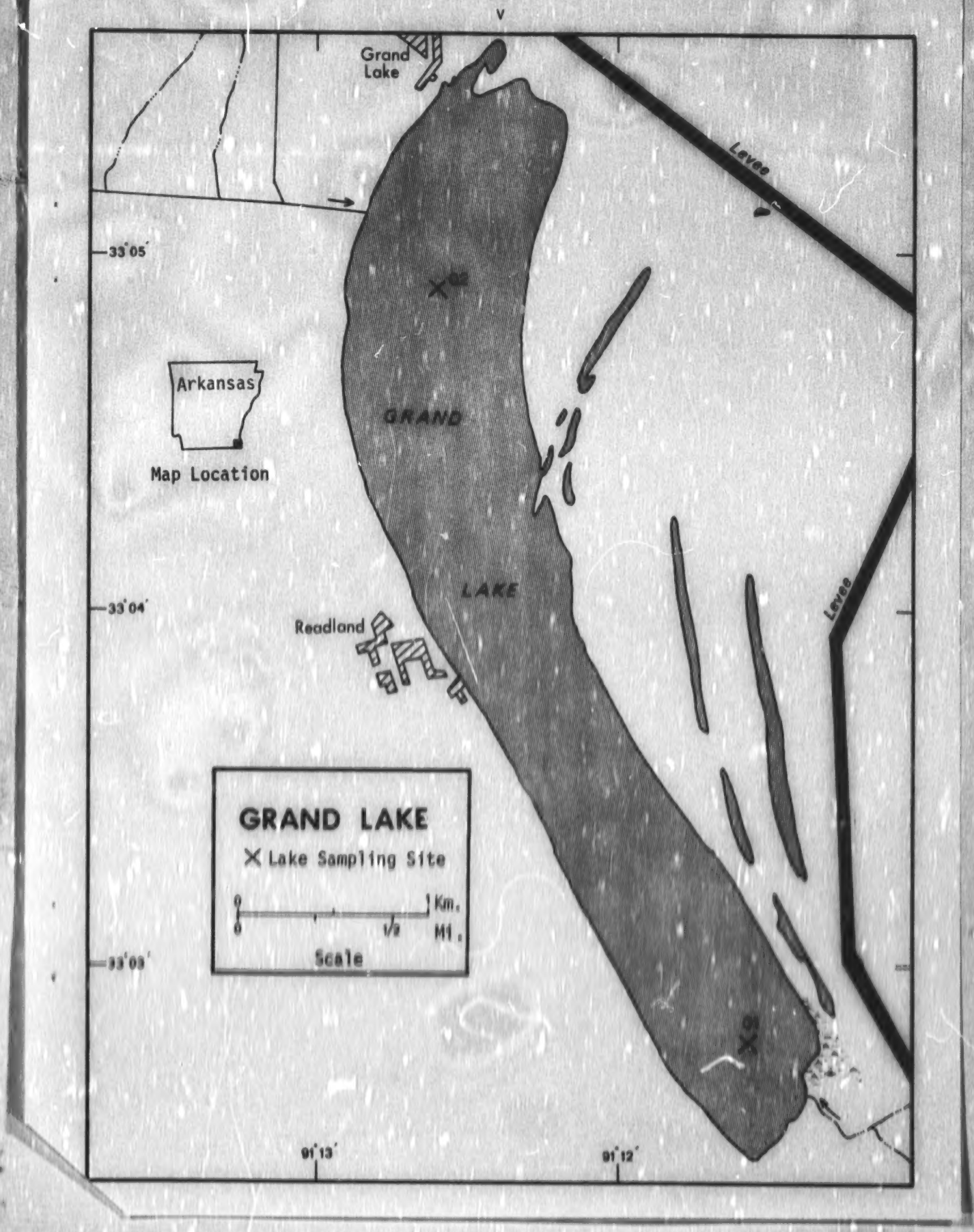
Major General Thomas C. Armstrong, the Adjutant General of Arkansas, and Project Officer Colonel Lavaun M. James, who directed the volunteer efforts of the Arkansas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF ARKANSAS

LAKE NAME	COUNTY
Beaver	Benton, Carroll, Washington
Blackfish	Crittenden, St. Francis
Blue Mountain	Logan, Yell
Bull Shoals	Baxter, Boone, Marion (Taney, Ozark in MO)
Catherine	Garland, Hot Spring
Chicot	Chicot
DeGray	Clark, Hot Spring
Erling	Lafayette
Grand	Chicot
Greer's Ferry	Van Buren, Cleburne
Hamilton	Garland
Millwood	Hempstead, Howard, Little River, Sevier
Nimrod	Perry, Yell
Norfork	Baxter, Fulton (Ozark in MO)
Ouachita	Garland, Montgomery
Table Rock	Boone, Carroll (Barry, Taney in MO)


Grand Lake
Levee
33°05'
Arkansas
Map Location
GRAND
LAKE
Readland
Levee
33°04'
GRAND LAKE
Lake Sampling Site
0
1 Km.
0
1/2
MI.
Scale
33°03'
91°13'
91°12'

REPORT ON GRAND LAKE, ARKANSAS

STORET NO. 0509

I. INTRODUCTION

Grand Lake was included in the National Eutrophication Survey (NES) as a water body of special interest to the Arkansas Department of Pollution Control and Ecology. Tributaries and nutrient sources were not sampled, and this report relates only to the data obtained from lake sampling.

II. CONCLUSIONS

A. Trophic Condition:*

Grand Lake is considered eutrophic, i.e., nutrient rich and highly productive, on the basis of Survey data and field observations. Whether such nutrient enrichment is to be considered beneficial or deleterious is determined by its actual or potential impact upon designated beneficial water uses of the lake.

Chlorophyll a levels ranged from 30.2 µg/l in the spring to 103.0 µg/l in the summer with a mean of 62.9 µg/l. Mean Secchi disc visibility was 51.6 cm (20 inches). Of the 16 Arkansas lakes sampled in 1974, 2 had greater median total phosphorus levels, 15 had greater median inorganic nitrogen values, and 2 had greater median orthophosphorus levels than Grand Lake.

*See Appendix C

Survey limnologists reported an algal bloom during autumn sampling and many submerged, emergent and floating aquatic macrophytes along the shoreline areas during all three sampling seasons.

B. Rate-Limiting Nutrient:

Algal assay results indicate that Grand Lake is limited by available nitrogen. Spikes with nitrogen alone or nitrogen and phosphorus simultaneously resulted in increased assay yields. The addition of orthophosphorus alone did not produce a growth response. The ratios of total inorganic nitrogen to orthophosphorus (N/P) in the lake data further substantiate nitrogen limitation.

III. LAKE CHARACTERISTICS

A. Lake Morphometry:*

1. Surface area: 5.67 km^2.
2. Mean depth: 2.1 meters.
3. Maximum depth: 4.0 meters.
4. Volume: 12.088 x 10^6 m^3.

B. Precipitation:

1. Year of sampling: 161.3 cm.
2. Mean annual: 160.3 cm.

*Woomer, 1974

IV. LAKE WATER QUALITY SUMMARY

Grand Lake was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and from a number of depths at each station (see map, page 1). During each visit, depth-integrated samples were collected from each station for chlorophyll a analysis and phytoplankton identification and enumeration. During the first visit, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 2.4 meters at Station 01 and 1.5 meters at Station 02. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix B and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll a determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

LAKE
T CODE 0509

A. PHYSICAL AND CHEMICAL CHARACTERISTICS

PARAMETER	(3/26/74) S*** = 2 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	(6/ 4/74) S*** = 2 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	(7/16/74) S*** = 2 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)
TEMPERATURE (DEG CENT)												
0.-1.5 M DEPTH	6	12.2- 12.3	12.2	0.0- 1.5	4	26.0- 27.2	26.6	0.0- 1.5	4	18.6- 19.1	18.9	0.0- 1.5
MAX DEPTH**	2	12.2- 12.2	12.2	1.5- 1.5	2	26.0- 26.5	26.3	1.2- 1.5	2	18.5- 19.1	19.8	1.5- 2.4
DISSOLVED OXYGEN (MG/L)												
0.-1.5 M DEPTH	4	10.8- 11.0	10.9	0.0- 1.5	1	13.0- 13.0	13.0	0.0- 0.0	4	6.8- 7.8	7.3	0.0- 1.5
MAX DEPTH**	2	10.8- 11.0	10.9	1.5- 1.5	0	***** *****	*****	***** *****	2	6.8- 7.6	7.1	1.5- 2.4
CONDUCTIVITY (UMHOS)												
0.-1.5 M DEPTH	6	158.- 158.	158.	0.0- 1.5	4	236.- 247.	242.	0.0- 1.5	2	161.- 161.	161.	0.0- 1.5
MAX DEPTH**	2	158.- 158.	158.	1.5- 1.5	2	243.- 247.	245.	1.2- 1.5	1	161.- 161.	161.	1.5- 1.5
PH (STANDARD UNITS)												
0.-1.5 M DEPTH	4	8.3- 8.5	8.5	0.0- 1.5	4	8.2- 9.1	8.2	0.0- 1.5	4	7.8- 7.9	7.9	0.0- 1.5
MAX DEPTH**	2	8.3- 8.5	8.4	1.5- 1.5	2	8.2- 9.0	8.6	1.2- 1.5	2	7.9- 7.9	7.9	1.5- 2.4
TOTAL ALKALINITY (MG/L)												
0.-1.5 M DEPTH	4	96.- 98.	97.	0.0- 1.5	4	89.- 95.	91.	0.0- 1.5	4	96.- 97.	95.	0.0- 1.5
MAX DEPTH**	2	96.- 97.	97.	1.5- 1.5	2	91.- 95.	93.	1.2- 1.5	2	95.- 95.	95.	1.5- 2.4
TOTAL P (MG/L)												
0.-1.5 M DEPTH	4	0.069-0.101	0.098	0.0- 1.5	4	0.073-0.120	0.094	0.0- 1.5	4	0.120-0.136	0.128	0.0- 1.5
MAX DEPTH**	2	0.069-0.101	0.085	1.5- 1.5	2	0.081-0.088	0.084	1.2- 1.5	2	0.120-0.134	0.127	1.5- 2.4
DISSOLVED ORTHO P (MG/L)												
0.-1.5 M DEPTH	4	0.027-0.030	0.029	0.0- 1.5	4	0.018-0.025	0.020	0.0- 1.5	4	0.014-0.021	0.015	0.0- 1.5
MAX DEPTH**	2	0.028-0.030	0.029	1.5- 1.5	2	0.019-0.025	0.022	1.2- 1.5	2	0.014-0.015	0.014	1.5- 2.4
NO2+NO3 (MG/L)												
0.-1.5 M DEPTH	4	0.030-0.040	0.030	0.0- 1.5	4	0.070-0.140	0.080	0.0- 1.5	4	0.020-0.020	0.020	0.0- 1.5
MAX DEPTH**	2	0.030-0.030	0.030	1.5- 1.5	2	0.070-0.080	0.075	1.2- 1.5	2	0.020-0.020	0.020	1.5- 2.4
AMMONIA (MG/L)												
0.-1.5 M DEPTH	4	0.040-0.070	0.045	0.0- 1.5	4	0.050-0.090	0.060	0.0- 1.5	4	0.040-0.080	0.040	0.0- 1.5
MAX DEPTH**	2	0.040-0.070	0.055	1.5- 1.5	2	0.050-0.090	0.070	1.2- 1.5	2	0.030-0.040	0.035	1.5- 2.4
KJELDAHL N (MG/L)												
0.-1.5 M DEPTH	4	0.900-1.400	1.000	0.0- 1.5	4	1.100-1.800	1.250	0.0- 1.5	4	1.200-3.000	1.400	0.0- 1.5
MAX DEPTH**	2	0.900-1.000	0.950	1.5- 1.5	2	1.200-1.300	1.250	1.2- 1.5	2	1.100-1.200	1.150	1.5- 2.4
SECCHI DISC (METERS)												
	2	0.6- 0.6	0.6		2	0.5- 0.6	0.5		2	0.4- 0.5	0.4	

* N = NO. OF SAMPLES
** MAXIMUM DEPTH SAMPLED AT EACH SITE
*** S = NO. OF SITES SAMPLED ON THIS DATE

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/26/74	1. Nitzschia	4,635
	2. Stephanodiscus	3,873
	3. Flagellates	2,467
	4. Chlamydomonas	2,[illegible]3
	5. Melosira	1,794
	Other genera	8,298
	Total	23,100
06/04/74	1. Dactylococcopsis	52,408
	2. Stephanodiscus	23,206
	3. Merismopedia	16,165
	4. Microcystis	11,472
	5. Lyngbya	10,429
	Other genera	39,112
	Total	152,792
10/16/74	1. Dactylococcopsis	3,523
	2. Oscillatoria	3,030
	3. Centric Diatom	2,924
	4. Microcystis	2,537
	5. Merismopedia	2,008
	Other genera	3,171
	Total	17,193

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
03/26/74	01	30.2
	02	36.3
06/04/74	01	103.0
	02	103.0
10/16/74	01	55.7
	02	49.0

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked - 03/26/74

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.020	0.039	3.8
0.05 P	0.070	0.039	3.3
0.05 P + 1.0 N	0.070	1.039	29.3
1.00 N	0.020	1.039	13.2

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential for primary production was high on Grand Lake during the spring sampling period. The lake was nitrogen limited at that time as indicated by the increased yield of the test alga in response to an addition of nitrogen. Spikes with nitrogen and phosphorus simultaneously resulted in maximum yield. Spikes with orthophosphorus alone did not produce a response significantly beyond the control yield.

The autumn algal assay results are not considered reliable because of a significant change in the nutrient levels between the time the sample was collected and the assay was begun.

The mean total inorganic nitrogen to orthophosphorus ratios (N/P) in the lake data were 3/1 in the spring, 8/1 in the summer and 4/1 in the fall, suggesting primary limitation by nitrogen (an N/P ratio of 14/1 or greater generally reflects phosphorus limitation).

V. LITERATURE REVIEWED

U.S. Environmental Protection Agency. 1975. National Eutrophication Survey Methods 1973-1976. Working Paper No. 175. National Environmental Research Center, Las Vegas, Nevada, and Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon.

Woomer, Neil. 1974. Personal Communication (morphometry data of Arkansas water bodies). Department of Pollution Control and Ecology, Little Rock, Arkansas.

VI. APPENDICES

APPENDIX A

CONVERSION FACTORS

II.

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX B

PHYSICAL AND CHEMICAL DATA

STORET RETRIEVAL DATE 74/11/14
NATL EUTROPHICATIO[illegible]
EPA-LAS VEGAS

050401
33 03 05.0 094 11 50.0
GRAND LAKE
05 ARKANSAS

11FEALES
3

2111202
0004 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/03/26	10 25	0000	12.2		24	158	8.45	98	0.050	1.400	0.040	0.030
	10 25	0002	12.2	10.8		158						
	10 25	0005	12.2	10.8		158	8.35	97	0.040	0.900	0.030	0.028
74/06/04	10 30	0000	27.2		18	230	8.60	89	0.060	1.800	0.140	0.021
	10 30	0005	26.0			247	8.20	95	0.090	1.200	0.080	0.025
74/10/16	10 25	0000	18.8	7.6	18		7.85	94	0.080	3.000	0.020	0.014
	10 25	0005	18.6	7.6			7.77	97	0.040	1.200	0.020K	0.021
	10 25	0008	18.5	7.5			7.84	95	0.030	1.100	0.020	0.015

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/03/26	10 25	0000	0.105	30.2	
	10 25	0005	0.069		
74/06/04	10 30	0000	0.120	103.0	
	10 30	0004			1.0
	10 30	0005	0.088		
74/10/16	10 25	0000	0.136	55.7	
	10 25	0005	0.122		1.0
	10 25	0008	0.134		

— K VALUE KNOWN TO BE LESS THAN INDICATED —

STORET RETRIEVAL DATE 74/01/14
NATL EUTROPHICATION SURVEY
EPA-LAS VEGAS

050902
33 04 45.0 091 12 40.0
GRAND LAKE
05 ARKANSAS

11EPALES 2111206
3 0007 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/03/26	10 45	0000	12.3		24	158	8.55	96	0.040	1.000	0.030	0.027
	10 45	0002	12.3	11.0		158						
	10 45	0005	12.2	11.0		158	8.50	96	0.070	1.000	0.030	0.030
74/06/04	11 00	0000	26.7	13.0	24	241	9.10	90	0.060	1.100	0.080	0.018
	11 00	0004	26.5			243	9.05	91	0.050	1.300	0.070	0.019
74/10/18	10 50	0000	19.1	7.8	14	161	7.95	94	0.040	1.600	0.020	0.017
	10 50	0005	19.1	6.5		161	7.87	95	0.040	1.200	0.020	0.014

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/03/26	10 45	0000	0.097	36.3	
	10 45	0005	0.101		
74/06/04	11 00	0000	0.073	103.0	
	11 00	0003			1.0
	11 00	0004	0.081		
74/10/18	10 50	0000	0.120	49.0	
	10 50	0003			1.0
	10 50	0005	0.120		

APPENDIX C

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1974

STATE OF ARKANSAS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG P	500-MEAN SEC	MEAN CHLORA	15-MIN OD	MEDIAN DISS ORTHO P
0501	BEAVER LAKE	0.726	1.337	415.667	3.421	14.900	0.004
0502	BLACKFISH LAKE	0.424	1.077	496.125	19.775	12.000	0.040
0503	BLUE MOUNTAIN LAKE	0.054	0.141	444.000	6.983	14.900	0.010
0504	BULL SHOALS LAKE	0.015	0.346	343.889	3.495	15.000	0.004
0505	LAKE CATHERINE	0.029	0.146	451.667	14.042	11.800	0.006
0506	LAKE CHICOT	0.162	0.452	445.000	13.722	14.800	0.009
0507	DEGRAY RESERVOIR	0.015	0.139	414.050	12.300	15.000	0.004
0508	LAKE ERLING	0.454	0.129	454.667	13.389	14.600	0.020
0509	GRAND LAKE	0.181	0.091	479.667	62.867	8.400	0.021
0510	LAKE HAMILTON	0.024	0.130	428.111	10.889	14.400	0.006
0511	MILLWOOD LAKE	0.048	0.120	466.778	14.967	9.000	0.008
0512	NIMROD LAKE	0.039	0.268	445.000	15.833	8.000	0.006
0513	NORFORK LAKE	0.015	0.320	356.321	3.441	15.000	0.005
0514	LAKE OUACHITA	0.015	0.256	399.144	4.344	15.000	0.006
0515	TABLE ROCK LAKE	0.022	0.350	418.778	9.183	15.000	0.007
0516	GREERS LAKE	0.012	0.140	378.875	3.762	15.000	0.004

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG P	500= MEAN SEC	MEAN CHLORA	15= MIN DO	MEDIAN DISS ORTHO P
0501	BEAVER LAKE	67 (99)	27 (41)	67 (101)	87 (131)	40 (61)	63 (91)
0502	BLACKFISH LAKE	0 (39)	0 (60)	0 (81)	7 (11)	73 (111)	0 (0)
0503	BLUE MOUNTAIN LAKE	26 (39)	47 (71)	13 (21)	67 (101)	57 (81)	27 (41)
0504	BULL SHOALS LAKE	99 (131)	13 (21)	100 (151)	80 (121)	17 (01)	93 (131)
0505	LAKE CATHERINE	47 (71)	40 (61)	47 (71)	27 (41)	80 (121)	63 (81)
0506	LAKE CHICOT	7 (11)	7 (11)	7 (11)	33 (51)	47 (71)	7 (11)
0507	DEGRAY RESERVOIR	73 (111)	77 (113)	60 (91)	47 (71)	17 (01)	93 (131)
0508	LAKE ERLING	27 (41)	90 (133)	40 (61)	40 (61)	57 (81)	20 (31)
0509	GRAND LAKE	13 (21)	100 (151)	20 (31)	0 (01)	100 (151)	13 (21)
0510	LAKE HAMILTON	53 (81)	77 (113)	53 (81)	53 (81)	67 (101)	63 (81)
0511	MILLWOOD LAKE	33 (51)	90 (133)	33 (51)	20 (31)	87 (131)	33 (51)
0512	NIMROD LAKE	40 (61)	53 (81)	27 (41)	13 (21)	93 (141)	47 (71)
0513	NORFORK LAKE	80 (121)	33 (51)	93 (141)	100 (151)	17 (01)	80 (121)
0514	LAKE OUACHITA	90 (133)	60 (91)	80 (121)	73 (111)	17 (01)	63 (81)
0515	TABLE ROCK LAKE	67 (91)	20 (31)	73 (111)	60 (91)	17 (01)	40 (61)
0516	GREER'S LAKE	100 (151)	67 (101)	87 (131)	93 (141)	17 (01)	93 (131)